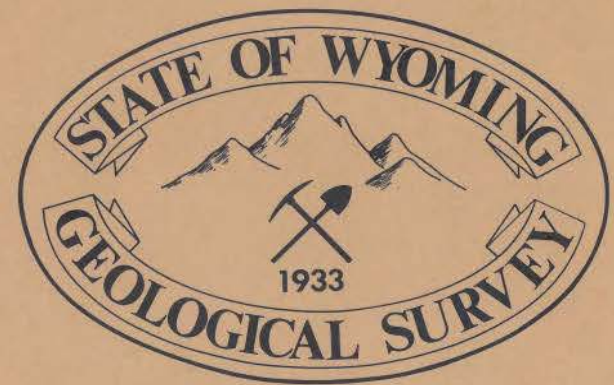


THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

WYOMING
GEO-NOTES
NO.6



Laramie, Wyoming
March, 1985

WYOMING GEO-NOTES

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Wyoming Geo-notes was first published in July, 1977, as a semiannual newsletter for the Geological Survey. It had a very shaky start which ended abruptly with a single issue, designated Volume 1, Number 1. The recent success of our *Quarterly Minerals Update for Wyoming*, however, has been so overwhelming that it now forms the backbone for our rejuvenated *Wyoming Geo-notes*. The newsletter is now published quarterly and has been expanded to include news about Staff and Survey activities.

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MINERALS UPDATE

OVERVIEW

by Gary B. Glass, State Geologist, Wyoming Geological Survey

In the last issue of *Wyoming Geo-notes*, I noted that our September production forecasts for oil, natural gas, and coal were all in need of upward revision. Although final numbers are not yet available for oil and gas production, even our revised December estimate of 125 million barrels of oil may fall as much as a million barrels short of the actual production. The revised estimate for natural gas is holding although it looks like it might be closer to 585 billion cubic feet of gas than 600 billion cubic feet.

But coal is the real surprise. In December, (*Wyoming Geo-notes* No. 5), we raised our earlier estimate of coal production from 120 million tons to 129 million tons. With the final figures now available from the State Inspector of Mines, coal production actually went to 130.7 million tons. This represents a whopping 16.5 percent increase over 1983.

Based on these revised figures or estimates for 1984, we have increased some of our near-term forecasts of oil, natural gas, and coal production above our previous forecasts of last year. These revised forecasts are presented in Table 1 (page 2). Briefly, oil production looks like it will hold steady for another year before it again slowly begins to decline, and we now see production remaining above 120 million barrels out through 1990. Natural gas

Table 1. Wyoming mineral production forecast to 1991¹

Calendar Year	Oil Production ²	Natural Gas Production ³	Coal Production ⁴	Trona Production ⁴	Uranium Production ⁴
*1981	122.1	455.4	102.8	11.8	4.6
*1982	118.7	465.1	107.9	10.1	2.1
*1983	120.9	539.7	112.2	10.5	3.0
1984	126.0	585.0	130.7*	10.4	1.2
1985	126.0	630.0	134.0	10.4	0.8
1986	125.0	675.0	138.0	10.5	0.50
1987	124.0	715.0	141.5	10.6	0.20
1988	123.0	750.0	143.3	10.8	0.20
1989	122.0	775.0	144.5	11.0	0.15
1990	120.0	800.0	145.5	11.2	0.15
1991	118.0	825.0	147.0	11.5	0.20

* Actual values for comparison, ¹ Wyoming Geological Survey, March, 1985, ² in millions of barrels, ³ in billions of cubic feet, ⁴ in millions of tons.

production will still show substantial increases each year, but at higher production levels than our past estimates. Coal, however, is not likely to repeat its spectacular growth of last year, and production reports for early 1985 suggest production is only keeping pace with 1984. We see only modest increases in coal production between 1985 and 1987 and nearly flat production levels between 1988 and 1990. Consequently, we only had to revise our 1985 forecast and the next two years as our 1988 through 1990 forecast still appears valid.

Our forecast for trona production is somewhat below last years, and reflects only very small increases in production beginning after this year. Our uranium forecast is very nearly the same as last year's forecast, and shows substantial declines in production at least through 1987. Production after 1987 will essentially level out.

In regard to prices, the price of oil is now close to \$26 per barrel. Natural gas and coal prices seem to be holding steady or falling only slightly. It is really still too early to feel any confidence in where prices are headed in 1985, particularly oil prices, which are still somewhat dependent on OPEC's plans or rather OPEC's ability to enforce its plans.

In closing, this issue of *Wyoming Geo-notes* also includes a summary article on Legislation considered or passed in the 1985 General Session (page 32).

OIL AND GAS UPDATE

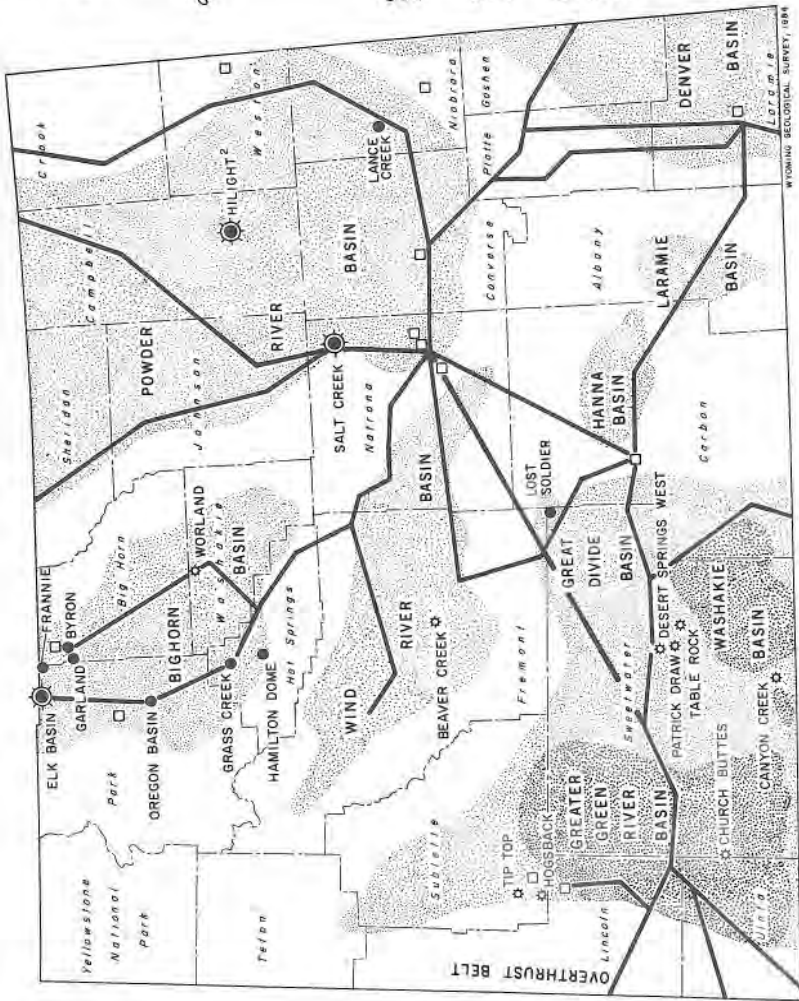
by Alan J. Ver Ploeg, Petroleum Geologist, Wyoming Geological Survey

Preliminary 1984 well completion statistics were recently released by Petroleum Information Corporation (1985). They are summarized and compared with 1982 and 1983 in the table below:

	<u>New field wildcats</u>				<u>All wells</u>			
	<u>Oil</u>	<u>Gas</u>	<u>Dry</u>	<u>Total</u>	<u>Oil</u>	<u>Gas</u>	<u>Dry</u>	<u>Total</u>
1984	57	9	440	506	801	142	750	1,693
1983	23	13	305	341	698	152	550	1,400
1982	68	28	404	500	1,029	272	827	2,128

The above numbers dramatically illustrate the decreased interest in gas exploration, and the concurrent increased interest in oil exploration during the last two years. Basically, decreasing consumption, which has led to an oil and gas surplus, and decreasing prices in the case of oil (average of \$31.77 per barrel in 1981, compared with \$26.00 per barrel in 1984) have been responsible for the decline in activity in Wyoming. It does appear, however, that this trend may be reversing as the total number of wells drilled increased from 1983 to 1984. The increase in new field wildcats is especially encouraging in terms of exploration trends. The majority of these new oil discoveries have been in the Powder River Basin as a result of the Minnelusa Play. Regionally, Wyoming was a close second to Colorado in total completions (1,693 to 1,745). Wyoming led the region in total footage drilled (12,153,100 feet), followed by Colorado (10,271,185 feet). The average depth for wells drilled in Wyoming was 7,178 feet. For 1984, rig activity ranged from 84 rigs to a high of 140, averaging 114.6. This was an increase from the average count of 95.6 for 1983. Petroleum Information Corporation (1985) also projects a slight increase in activity for 1985, possibly 2-4 percent in terms of completions for Wyoming. They also project a slight increase in oil demand which will be needed to stimulate drilling.

High bids from competitive oil and gas lease sales on Federal lands in Wyoming totaled \$29.5 million in 1984, an increase of more than \$25 million from the money received from similar sales in each of the two previous years. The U.S. Bureau of Land Management noted that this increase was in a large part a result of offering 542 parcels in 1984 as compared to 162 in 1983 and 121 in 1982. And the February 1985 auction did indicate a decline in revenues from 1984 rates.



EXPLANATION

- Major Wyoming Basins
- Oil shale occurrences
- Oil and gas pipeline corridors
- Refineries

- Oil field with cumulative production¹ greater than 100 million barrels
- Gas field with cumulative production¹ greater than 200 billion cubic feet
- Oil and gas field with cumulative production¹ greater than 100 million barrels and cumulative production² of gas greater than 200 billion cubic feet

¹ CUMULATIVE PRODUCTION IS THROUGH 1981
² CUMULATIVE OIL PRODUCTION OF LIGHT FIELD WAS 50 MILLION BARRELS THROUGH 1981

GENERALIZED OIL AND GAS INDEX MAP OF WYOMING

WYOMING GEOLOGICAL SURVEY, 1984

Wyoming's State oil and gas lease sale revenues are also on the decline. For fiscal year 1984, Wyoming saw an average of \$26.28 per acre offered and \$32.50 for each acre leased. So far in fiscal year 1985, the average is \$22.60 for each acre offered and \$26.46 for each acre leased. State lease sales in Montana, Colorado, Utah, and North Dakota are also reportedly showing declines in revenue.

On a related note, the State Land Commissioner's office is continuing efforts to revise the State's oil and gas lease form. Key issues, which are being contested by oil industry representatives, include accounting provisions, a provision ensuring royalties are based on the market value for the product, and stiffened penalties for noncompliance with the lease.

Another large natural gas plant is being planned in the Overthrust area by Chevron U.S.A., Inc. The plant will serve East Painter Reservoir Field and Clear Creek Field, northeast of Evanston, Wyoming. The project will cost \$180.6 million and will have a maximum capacity of 240 million cubic feet of gas per day.

Development of Exxon's high carbon dioxide (CO₂) gas in the Riley Ridge area remains in the news. It now appears that in addition to the enhanced oil recovery projects in Rangely, Colorado, and near Bairoil, Wyoming, the Powder River Basin of northeastern Wyoming and the Williston Basin of North Dakota are potential markets. These additional markets will necessitate the construction of a 642-mile pipeline from Rock Springs, Wyoming, to Tioga, North Dakota, plus an 18-mile spur to Bairoil, Wyoming, for a total of 660 miles of pipeline. Two lines are currently being considered for the segment from Rock Springs to Bairoil, one proposed by Exxon and one by Amoco. The two lines could, however, be

combined into one. The segment from Bairoil to Tioga is just one line as proposed by Exxon.

Exxon's La Barge Project, which would supply the CO₂, is the largest industrial facility ever reviewed under the 10-year-old Industrial Siting process. The \$2.2 billion plant includes several stages of development that could lead to a plant capable of producing over 1.86 billion cubic feet of gas per day, and which would have peak construction work forces in excess of 5,200 workers.

The U.S. Department of Energy has awarded University of Wyoming researchers a \$151,600 grant for a study of new enhanced oil recovery techniques for removing huge oil reserves currently locked up in known fields. The University researchers estimate there are 18 billion barrels of oil in Wyoming beyond the reach of conventional techniques. The grant covers research through August of 1986 and Assistant Professor David L. Whitman of the Petroleum Engineering Department, is the director for the project.

Also relating to enhanced oil recovery, the U.S. Department of Energy is working on a recovery project in the Shannon reservoir in the Teapot Dome area in Natrona County, Wyoming. Steam will be injected into a 20-acre area in an attempt to increase oil recovery to 30 percent. If successful, 54 million barrels of the oil-in-place might be recoverable from the reservoir, compared to conventional techniques which may only recover an estimated five percent or nine million barrels.

New enhanced oil recovery operations in Wyoming were given a tax break in the 1985 Wyoming Legislative Session. See the discussion on page 32 of this issue of *Wyoming Geo-notes*.

New Discoveries

Bennett Petroleum recovered 200 barrels of oil on a production test of the Cretaceous Muddy "J" sandstone, eight miles south of Torrington. The potential new field discovery produced oil from perforations at 7,046-7,058 feet.

A new Hoback Basin gas discovery, twenty-two miles northwest of Pinedale, was completed by Home Petroleum. The discovery produced 320,000 cubic feet of gas per day from Cretaceous Dakota Sandstone. Production was from about 2,300 feet.

Milestone Petroleum recently completed two new Powder River Basin oil discoveries. Milestone opened a new pay discovery (Shannon Sandstone) in Lucky Lindy Field, flowing 230 barrels of oil per day. The field already produces from the Dakota, Turner, and Parkman sands. Also, nineteen miles northeast of Lance Creek Field in Niobrara County, the company completed a wildcat for 318 barrels of oil per day from the Dakota.

Diamond Shamrock Exploration reported the completion of another prolific Minnelusa discovery, twenty-one miles northwest of Moorcroft. The well was completed for 1,025 barrels per day from 7,011 feet.

Diamond Shamrock also recently completed a Frontier oil and gas discovery in the southern Powder River Basin, thirty miles north of Glenrock near Buck Draw Field. Production tests yielded 158 barrels of oil and 245,000 cubic feet of gas per day from a depth of 12,670-12,724 feet. In addition, they completed another Frontier discovery five miles south of Ross, Wyoming, producing 1,067 barrels of oil and 1,980,000 cubic feet of gas per day from the Frontier.

W.A. Moncrief completed a Frontier discovery eighteen miles southeast of Sussex in Johnson County. The well, which is over 12,000 feet deep, flowed 200 barrels of oil and 250,000 cubic feet of gas per day.

Hrubetz Oil announced completion of a 765-barrel per day oil discovery ten miles southeast of Gillette. The well produces from the Minnelusa between 9,998 and 10,033 feet.

As the above discoveries illustrate, the Powder River Basin remains the hot spot for Wyoming oil exploration.

References

Petroleum Information, 1985, *1984 Annual review: Rocky Mountain Region Report 1-10-85*, p. 9-10.

COAL UPDATE

by Richard W. Jones, Coal Geologist, Wyoming Geological Survey

Preliminary data from the State Inspector of Mines indicate that Wyoming's coal production in 1984 was 130.7 million tons (Table 2), an increase of 16.5 percent over 1983's record 112.2 million tons. This is the highest annual rate of increase since 1980. Reported deliveries for 11 months of 1984 are included for comparison (Table 3).

The unexpected surge in production from the Powder River Basin accounted for most of the increase: the 112.7 million tons produced from this basin in 1984 was up 20 percent over 1983. Coal production from Campbell County increased over 20 percent in 1984;

Table 2. 1984 Wyoming coal production by county and by coal basin¹.

County	Production ²	Percent of Total Production	Number of Mines	Number of Employees
POWDER RIVER BASIN				
Campbell	106,804,621	81.7	14	2,773
Converse	3,338,677	2.6	1	264
Sheridan	2,516,979	1.9	2	221
TOTAL	112,660,277	86.2	17	3,258
GREEN RIVER BASIN				
Sweetwater	8,878,033	6.8	3	953
HAMS FORK REGION				
Lincoln	4,069,771	3.1	2	463
HANNA BASIN				
Carbon	5,095,008	3.9	5	658
BIGHORN BASIN				
Hot Springs	42,690	<0.1	1	4
TOTAL WYOMING				
	130,745,779	100	28	5,336

¹Source: Wyoming State Inspector of Mines, 1984 Annual Report (in preparation).

²Production in tons.

this county alone now accounts for nearly 82 percent of Wyoming's production. The Powder River Basin now accounts for about 86 percent of the State's production.

A total of 28 coal mines reported coal production in 1984, with 16 mines reporting increased production, and 12 mines reporting decreased production (Figure 1). Five of the State's coal mines produced over ten million tons each, including Thunder Basin Coal Company's Black Thunder Mine. With 1984 production of 21.2 million tons of coal, Black Thunder remains the biggest coal mine in the Nation and one of the most productive mines in the world. Kerr-McGee's Jacobs Ranch Mine (14.4 million tons) is now second in production, ahead of Amax's Belle Ayr and Eagle Butte Mines (13.4 million tons each). Thirteen of the Powder River Basin's 17 coal mines and 17 of the State's 28 coal mines produced in excess of two million tons each in 1984.

Despite the surge in coal production, employment at Wyoming coal mines decreased slightly in 1984 (Table 2). Current employment of 5,336 is at the lowest level since 1979. (Note: The preliminary employment number for 1983 given in *Wyoming Geo-notes No. 2* in March, 1984, should be adjusted upward to 855 for Carbon County and 5,401 for the State total.) An increase of 187 employees in the Powder River Basin in 1984 was more than offset by decreases of 197 in the Hanna Basin, 41 in the Green River Basin, and 14 in the Hams Fork Region. The employment decreases combined with the production increases mean that productivity (tons per miner) increased in 1984, and reflect a shift to the larger, less labor intensive surface mines in the Powder River Basin as well as a statewide increase in overall mining efficiency.

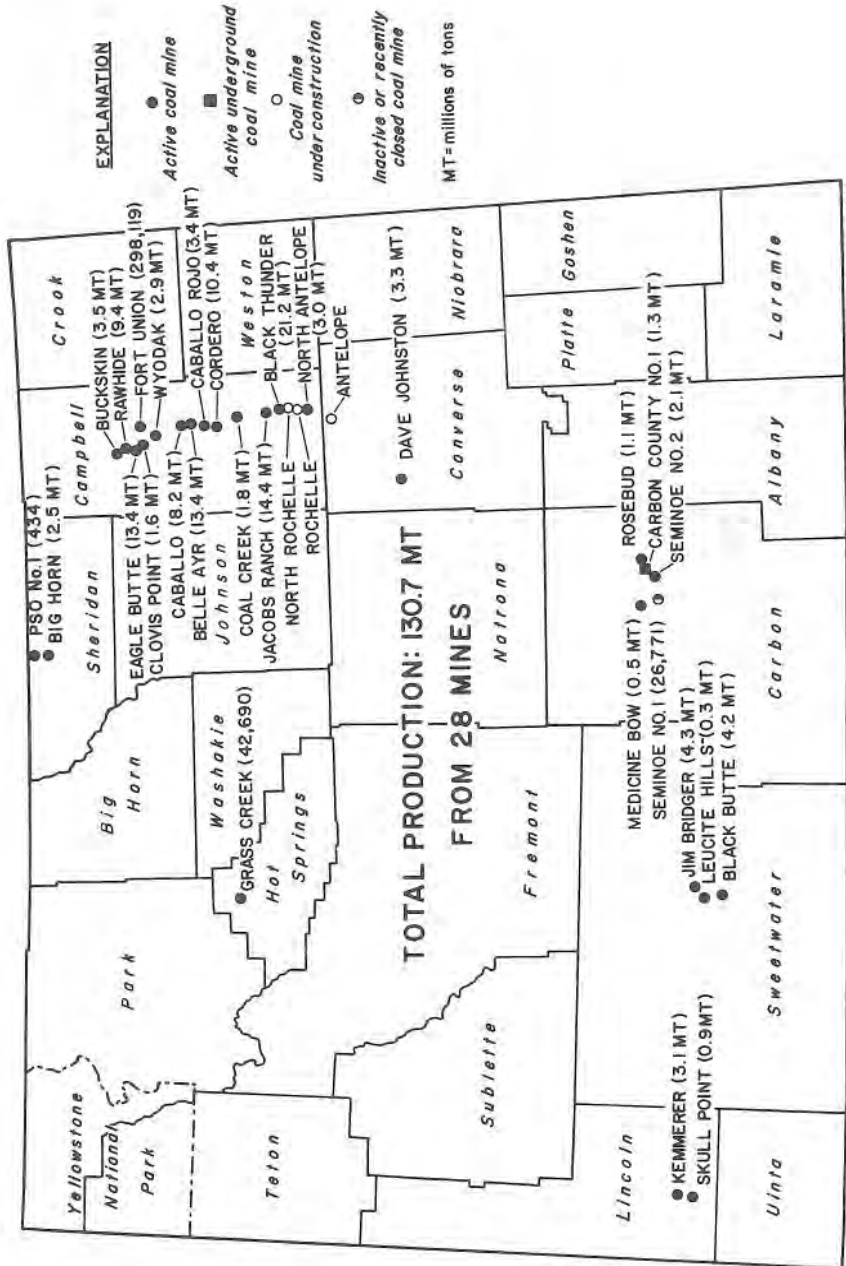
Table 3. Coal deliveries from Wyoming, in thousands of short tons, 1983 and 1984.

	REPORTED DELIVERED TONNAGE ¹			
	1983 MONTHLY	1983 CUMULATIVE	1984 MONTHLY	1984 CUMULATIVE
JANUARY	10,313.0	10,313.0	9,540.2	9,540.2
FEBRUARY	8,719.7	19,032.7	9,654.6	19,194.8
MARCH	9,051.2	28,083.9	0,875.0	30,069.8
APRIL	8,195.0	36,278.9	8,721.4	38,791.2
MAY	8,364.6	44,643.5	9,481.5	48,272.7
JUNE	8,330.2	52,973.7	9,464.5	57,737.2
JULY	8,734.7	61,708.4	11,019.6	68,756.8
AUGUST	9,669.3	71,337.7	11,433.0	80,189.8
SEPTEMBER	9,189.7	80,567.4	10,440.0	90,629.8
OCTOBER	9,406.3	89,973.7	10,492.5	101,122.3
NOVEMBER	9,013.6	98,987.3	11,814.2	112,936.5
DECEMBER	7,680.6	106,667.9		
TOTAL	106,667.9			
TOTAL TONNAGE NOT REPORTED ²				
	5,520.0			
TOTAL TONNAGE PRODUCED ³				
	112,187.9	130,745.8		

¹ Source: National Marketing Reports by Coal Market-ronix, compiled from FERC Form 423 filed monthly by electric utilities.

² Includes industrial, residential/commercial, and smaller utility sales.

³ Source: Wyoming State Mine Inspector's Annual Report for 1983 and for 1984 (in preparation).



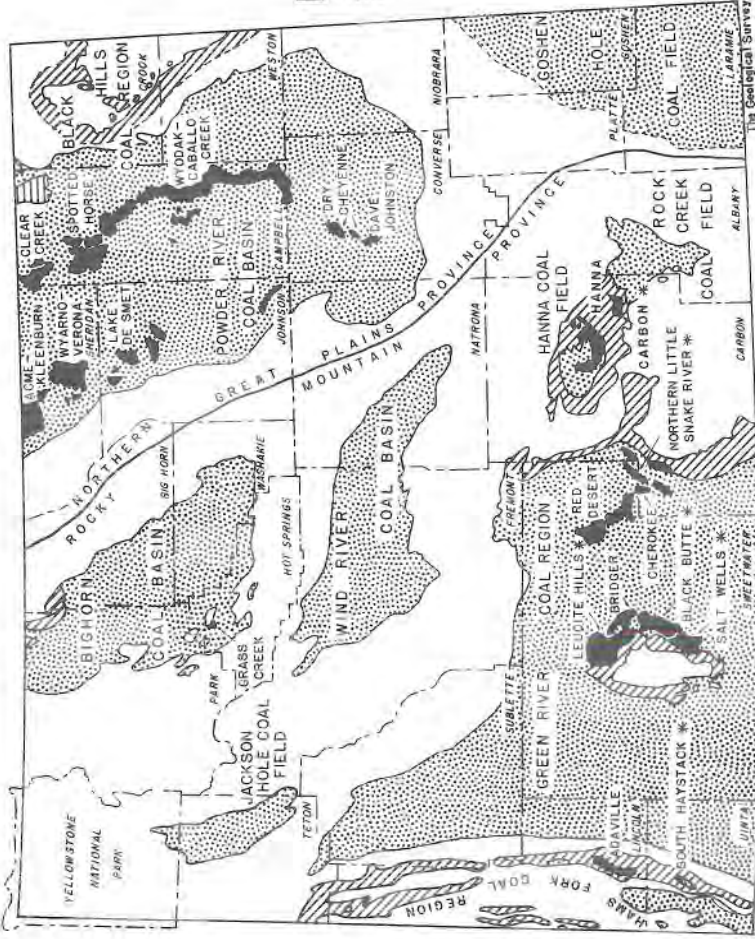
Wyoming Geological Survey, 1985

Figure 1. Wyoming coal mines and production, 1984.

EXPLANATION

-  Subbituminous
-  Bituminous
-  Lignite
-  Strippable Deposits

* Preliminary based on company data



The Geological Survey
of Wyoming
1964

COAL-BEARING REGIONS OF WYOMING

Wyoming continued as the third largest coal producer in the Nation, behind Kentucky's 165.5 million tons and only 0.2 million tons behind West Virginia's 130.9 million tons. National coal production of 890.1 million tons in 1984 set a new single-year record that was 13.8 percent higher than 1983 production (782 million tons) and 6.2 percent higher than 1982 production (838 million tons)-the previous record year. Wyoming now accounts for almost 15 percent of the Nation's coal production and about one-fourth of the Nation's production from surface mines. Contributing to the U.S. and Wyoming production increase was the six to seven percent increase in coal consumption (related to continued economic expansion) reported by electric utilities for 1984. The national increase was aided by the build-up of coal stocks by utilities in anticipation of a United Mine Workers' strike that never materialized. This build-up of coal stocks was most probably not a strike-related factor in Wyoming coal production increases, but instead, was probably a build-up in response to the availability of very low-priced coal from large mines plagued with excess capacity.

Production projections for 1985 for both Wyoming and the U.S. will probably parallel one another. Since neither coal consumption nor demand for electricity is expected to grow more than a few percent in 1985, we have projected that Wyoming's coal production will increase by 2.5 percent to 134 million tons (Table 4).

Production for the Powder River Basin, which was near or even above contracted production in 1984, is expected to remain at approximately the same level in 1985; statewide production was only two percent less than contracted production in 1984 and is expected to remain at this level in 1985 (implying less than contracted production or lost contracts in southern

Table 4. Coal production and forecast to 1990 (millions of tons).

	1981 ¹	1982 ¹	1983 ¹	1984 ¹	1985	1986	1987	1988	1989	1990
Campbell County	71.6	81.2	88.2	106.8	109.2	111.5	112.0	112.5	113.0	113.2
Converse County	3.6	3.4	2.7	3.3	5.4	5.0	6.0	6.3	6.3	8.6
Sheridan County	2.8	3.0	2.9	2.5	3.0	3.0	3.0	3.0	2.7	1.2
Carbon County	8.5	5.0	4.8	5.1	5.0	5.0	5.0	5.0	5.0	5.0
Sweetwater County	11.2	11.0	9.5	8.9	9.5	9.5	10.5	11.5	12.5	12.5
Lincoln County	5.0	4.3	4.0	4.1	4.0	4.0	5.0	5.0	5.0	5.0
Hot Springs County	M ²	M	M	M	M	M	M	M	M	M
Total Wyoming	102.8	107.9	112.2	130.7	134.0	138.0	141.5	143.3	144.5	145.5
Increase per year	9%	5%	4%	16.5%	2.5%	3%	2.5%	1%	1%	1%
Estimated contract-										
ed production	110.0	119.0	122.6	133.0	137.0	143.0	144.5	144.5	144.5	145.5
Below contract	7%	9%	8%	2%	2%	4%	2%	1%	0%	0%

¹ These are actual values for comparison. ²M means minor tonnage (less than 0.1 million tons). Forecast by Wyoming Geological Survey, March, 1985

Wyoming). From 1986 to 1990, we expect to see the production curve flatten out, with annual rates of increase declining from three percent to one percent. Similarly, the amount of production below contract amounts will become less and less. By 1990, it is expected that both actual production and contracted production will reach 145.5 million tons.

In coal market news, a Hanna Basin mine, Arch Mineral Corporation's Seminole No. 2, announced that 12 employees had been laid off. Production decreases related to a reduction in coal sales caused the mine to cut back to a five-day schedule, take a dragline out of operation, and to lay off the workers late in 1984. Also in the Hanna Basin, the State's only operating underground mine, Carbon County Coal Company's Carbon County No. 1, announced in November of 1984 that Northern Indiana Public Service Company (NIPSCO), the mine's only customer, was changing from a monthly to a weekly shipment schedule. The coal company also announced that they were gathering information in the Hanna area on the possible impacts of this mine closing down. Although no plans for layoffs or shutdowns have been announced, Carbon County Coal Company's contract with NIPSCO is scheduled to be renegotiated in June of 1985. Coal from this mine is currently the highest quality coal mined in the State (as-received heating values of 11,000+ British Thermal Units/pound) but it is also the most expensive coal (both F.O.B. and delivered) in the State.

The only mine in the Bighorn Basin of northwestern Wyoming (Hot Springs County), Northwestern Resources' Grass Creek strip mine, appears to have a new coal contract. Holly Sugar Company announced in February that their sugar beet processing plant at Worland would be converted to coal-fired boilers in 1986 and would use 170 tons of coal daily for its five months

of operation, for a total of 25,500 tons. The Grass Creek Mine, located about fifty-five miles west of Worland, produces a high quality high volatile C bituminous coal in a surface mining operation that is rumored to be the only mine west of the Mississippi using a mountain-top removal method of mining. The mine produced 42,690 tons of coal in 1984 and had four employees.

The most significant news in Wyoming's coal transportation industry in early 1985 was the announcement that the Chicago and North Western Transportation Company (C&NW) was planning to extend its new line in the southern Powder River Basin about ten miles farther north in order to serve three additional coal mines. The present rail line, which was completed in 1984 as a joint venture with Union Pacific (UP), now serves only the southern mines in the basin, mainly the North Antelope, Black Thunder, Jacobs Ranch, and Coal Creek. The proposed extension would give Carter Mining Company's Caballo, Amax Coal Company's Belle Ayr, and Mobil Coal Producing's Caballo Rojo Mines a choice of railroads to haul their coal. These three mines currently are only served by Burlington Northern. The new line proposed by C&NW is expected to cost about \$25 million and would probably double this railroad's present potential for contracts. Sunedco Coal Company, which owns the Cordero Mine (between Coal Creek and Caballo Rojo Mines), is expected to announce that they will build a short spur line to connect with Coal Creek.

In related news, C&NW and UP, the partners in the joint venture railroad, recently signed another coal-hauling contract. The new long-term agreement is the fourth major contract signed by the companies and calls for hauling about 1.8 million tons per year from Kerr-McGee's Jacobs Ranch Mine to Central Louisiana Electric's Rodemacher Plant in Louisiana.

METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel, Deputy Director, Wyoming Geological Survey

To generally summarize the State's metals activity for the past quarter - it was slow as would be expected at this time of the year. Some of the reported activities of interest to Wyoming include:

- 1) U.S. Steel Corporation's sale of the Atlantic City iron mine to Universal Equipment Company;
- 2) the purchase of Superior Oil Company and its Minerals Group by Mobil Oil - Superior has gold and diamond interests in Wyoming;
- 3) continued dewatering of the historic Carissa gold mine;
- 4) proposed placer gold-platinum dredging in the Douglas Creek District; and,
- 5) compilation of preliminary results on diamond-bearing kimberlite exploration research; mapping and wall-rock alteration studies in the Lewiston gold district; and mapping and studies of the economic geology of the Copper Mountain District in the Owl Creek Mountains by the Geological Survey of Wyoming's Metals Section.

The sale of the Atlantic City iron ore mine to Universal Equipment Company ended more than two decades of ownership by U.S. Steel Corporation. From 1962 to 1983, more than 90 million tons of iron ore were produced and shipped to the Geneva Steel Works near Provo, Utah. The remaining iron resources at the mine are unknown although it has been reported

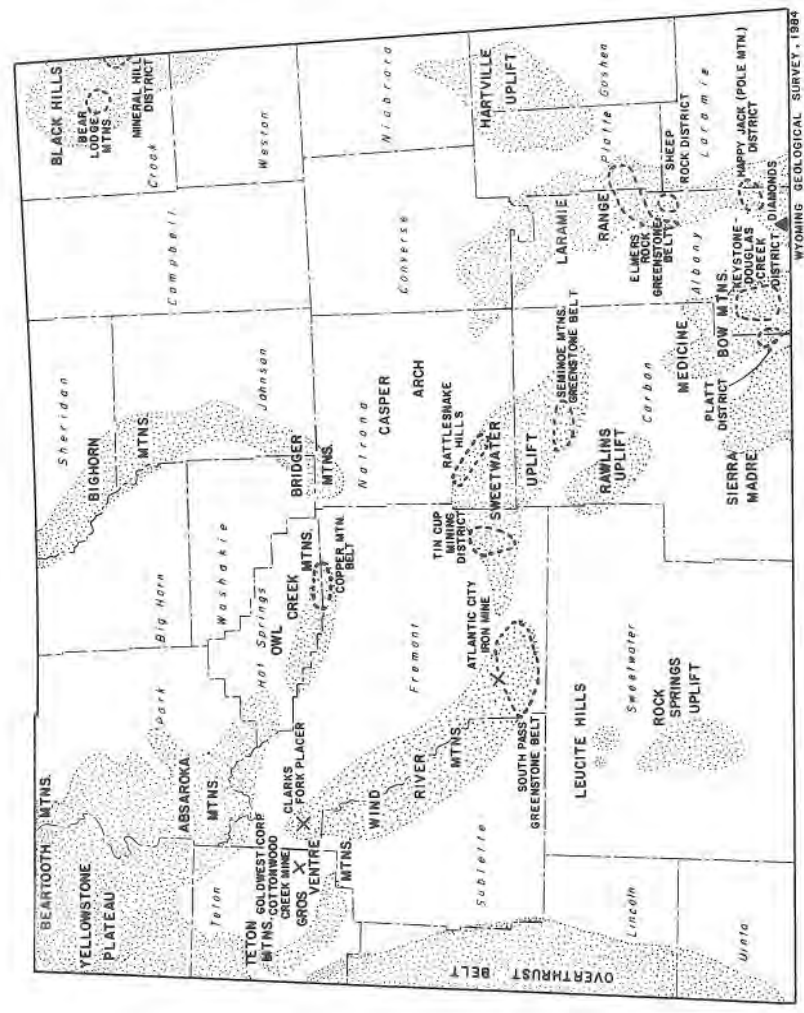
that at least ten years of reserves (? 50 million tons) are present. (See later discussion of the Atlantic City Mine on page 25).

Universal presently has a contract with the State Highway Department to supply road aggregate from mine dump tailings. The company also plans to sell all mobile mining equipment from the property, but no other plans have been made public.

Superior Oil Company's Minerals Group is in danger of being disbanded or sold by Mobil Oil. Superior has been exploring for Witwatersrand-type gold deposits in Wyoming and for diamondiferous kimberlite in the Colorado-Wyoming State Line District. Superior's diamond program has had promising results. Testing of the Sloan 1 and 2 pipes in the State Line District resulted in the recovery of an average grade of 0.2 carat per ton (Gold, 1984, p. 39). Commercial deposits range from 0.01 carat to as high as the unusually rich Australian Argyle pipe which has grades up to 6.8 carats per ton. Average diamond ore runs about 0.25 carat per ton.

At the low end of the commercial grade deposits, a diamond deposit must be supplemented by periodic finds of very large gem quality diamonds which so far are lacking in the State Line District. Diamonds recovered from the State Line District have been up to one carat with gem quality to industrial quality ratios typical of many South African deposits (about 10 to 20 percent gems).

Dewatering of the Carissa gold mine near South Pass City continues. This mine is reportedly one of the two largest historic producers of lode gold in the State. Estimated production was about 52,680 ounces of gold (Hausel, 1980, p. 7). The average grade of ore was reported as 0.32 ounce of gold per ton.



WYOMING GEOLOGICAL SURVEY, 1984

REGIONS OF EXPLORATION ACTIVITY FOR STRATEGIC MINERALS

EXPLANATION

X
Mines and gold placers

▲
Diamond localities

○
Mine district or supracrustal belt

●
Uplifted areas

MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM

Remaining Resources (January 1, 1984)	
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques) ¹	13.6 billion barrels ¹
Undiscovered	<u>7.6 billion barrels¹</u>
Total	21.2 billion barrels
Remaining Reserve Base (January 1, 1984)	
Measured reserves (Proved reserves) ²	0.8 billion barrels ²
Indicated and Inferred reserves ³	<u>2.8 billion barrels³</u>
Total	3.6 billion barrels

NATURAL GAS

Remaining Resources (January 1, 1984)	
Discovered	20.4 trillion cubic feet
Undiscovered (there is another 35 trillion cubic feet of noncombustible CO ₂ gas)	<u>58.0 trillion cubic feet</u>
Total	78.4 trillion cubic feet
Remaining Reserve Base (January 1, 1984)	
Measured reserves (Proved reserves)	9.6 trillion cubic feet

COAL

Remaining Resources (January 1, 1985)	
Identified (Discovered)	136.4 billion tons ⁴
Undiscovered	<u>800.0 billion tons⁵</u>
Total	936.4 billion tons
Remaining Reserve Base (January 1, 1985)	
Demonstrated strippable (Measured and indicated reserve base)	27.5 billion tons ⁴
Demonstrated underground-minable (Measured and indicated reserve base)	<u>38.4 billion tons⁴</u>

Total.....	65.9 billion tons
<u>TRONA</u>	
Original Resources	
Trona.....	81.7 billion tons ⁶
Mixed trona and halite.....	52.7 billion tons ⁶
Total.....	134.4 billion tons
<u>URANIUM</u>	
Remaining Resource (January 1, 1983).....	995,000 tons ⁷
Remaining Reserve Base (January 1, 1983)	
	<u>ORE</u>
	<u>U₃O₈</u>
Ore recoverable at \$30 or less/ton.....	29.4 million tons..... 39,700 tons ⁷
Ore recoverable at \$30.01-\$50.00/ton.....	225.1 million tons..... 151,500 tons ⁷
Ore recoverable at \$50 or less/ton.....	254.5 million tons..... 191,200 tons
<u>OIL SHALE</u>	
Original Resources (January 1, 1983)	
Identified (Discovered).....	320 billion barrels of shale oil ⁸

¹ Modified from Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.
² American Petroleum Institute, 1983, Basic petroleum data book: Volume III, no. 2, May.

³ Modified from Barlow and Doelger (1983), footnote 1.

⁴ Wyoming Geological Survey, March, 1985. (Modified from Berryhill, H.L., Jr. and others, 1950, Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.)

⁵ Averitt, Paul, 1975, Coal resources of the United States: U.S. Geological Survey Bulletin 1412, p. 15.

⁶ Culbertson, W.C., 1983, Genesis and distribution of trona deposits in Wyoming (abstract) in *Genesis and exploration of metallic and nonmetallic mineral and ore deposits of Wyoming and adjacent areas: Geological Survey of Wyoming Public Information Circular 19*, p. 34.

⁷ U.S. Department of Energy, 1983, Statistical data of the uranium industry: Open-file Report GJO-100-(83), 77 p.

⁸ Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

A Wyoming prospector is seeking a small mining permit to dredge parts of Douglas Creek for gold and platinum. The Douglas Creek-Keystone District on the east flank of the Medicine Bow Mountains is a well-known gold-copper-platinum district. Portions of Douglas Creek were last dredged in 1958. Total gold production from both placer and lode deposits in this district is estimated at 12,500 ounces (Curry, 1965).

During the past quarter, the Geological Survey of Wyoming's Metals Section compiled data and analyses of samples from the Lewiston District. A preliminary map of the district was prepared (Hausel, 1984), and some results on wall-rock alteration and mineralization are in preparation for publication.

Interesting assays of some selected and grab samples in the Lewiston District include:

<u>Mine Name</u>	<u>Gold (ounce/ton)</u>
Gold Leaf	1.29
Iron Duke	0.21
Hidden Hand	0.05
Bobtail (Good Hope)	1.18
Wolf	0.68

The Survey's stream sediment sample concentrates, which were panned from streams in the central Laramie Range, continued to produce kimberlitic satellite minerals. In one sample taken in the Silver Crown District, several flakes of gold were also found.

More than two dozen heavy mineral (pyrope garnet, chromian diopside, picro-ilmenite) anomalies have been identified in the Pole Mountain-Happy Jack region to the west of Cheyenne. Based on the sample distribution, several kimberlite intrusives are required to explain the anomalies. To date, only one 100-foot diameter pipe has been discovered in the

region by the Geological Survey of Wyoming. Samples from the Pole Mountain pipe and samples of lamproite collected from the Leucite Hills in the Green River Basin are being tested for diamond.

A report on the supracrustal rocks and economic geology of the Copper Mountain District in the Owl Creek Mountains has been published (Hausel and others, 1985) by the Geological Survey of Wyoming. The report describes the potential for stratiform gold and tungsten deposits in the region and examines a well-mineralized 30- to 50-foot wide tholeiitic dike that hosts significant copper, gold, and silver. (See page 42 of this issue).

In addition to these reported activities by the Metals Section of the Geological Survey of Wyoming, the Section has begun an extensive study of the geology of Wyoming's strategic mineral deposits. In this and future issues of *Wyoming Geo-notes*, a different strategic mineral deposit will be *highlighted*. This issue's *highlighted* deposit is the Atlantic City Mine.

Atlantic City Mine

The iron-formation which was mined at the Atlantic City open pit through 1983, is part of the Goldman Meadows Formation (see discussion of mine closure on page 19) This formation is predominantly metasedimentary and consists of iron-formation, schist, and quartzite. At the mine location, the iron-formation was structurally thickened by internal folding and plication.

At the Atlantic City Mine, the iron-formation, or taconite, consists of banded quartz-rich layers alternating with iron-rich magnetic layers that con-

tain blue-green hornblende and nearly colorless grunerite with some garnet, chlorite, and actinolite. The average iron content of the taconite ore is about 30 percent total iron. Selvages of quartz-chlorite schist, chlorite-garnet schist, and chlorite-amphibole-garnet magnetite hornfels are interlayered with the iron-formation. Both the iron-formation and selvages contain localized sulfides. The sulfides are euhedral to anhedral pyrite and chalcopyrite, and are found confined to foliation planes as well as in cross-cutting fractures and veinlets. The habit of the sulfides suggest that they are syngenetic, and in places, remobilized.

The potential for gold in the iron-formation is strengthened by a report that the historic Lone Star gold mine was developed on a vein in, or adjacent to, the iron-formation. This mine produced an estimated 2,100 ounces of gold (see Hausel, 1980, p. 7), and was reportedly located adjacent to the U.S. Steel iron mill. The mine location has long since been covered by mine tailings.

The Goldman Meadows Formation underlies the South Pass supracrustal belt. The entire belt forms a large synclinorium with Goldman Meadows metasediments cropping out along the northwest and eastern flanks of the belt. Near the Lewiston gold district on the opposing limb of the synclinorium from the Atlantic City Mine, a small wedge-shaped exposure of iron-formation with enclosed selvages is gold-bearing. Samples from this iron-formation assayed 0.01 to 0.04 ounce of gold and a trace to 0.10 ounce of silver per ton.

Whether or not the iron-formation in the Goldman Meadows Formation contains commercially valuable gold mineralization is not known. It appears, however, that at least minor amounts of gold are present.

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URANIUM AND INDUSTRIAL MINERALS UPDATE

by Ray E. Harris, Uranium and Industrial Minerals Geologist, Wyoming Geological Survey

Uranium

Layoffs continued within the uranium industry. Between March 1 and July 1, Pathfinder Mines, a branch of the French Company COGEMA, will lay off about half of its work force at Gas Hills. These

layoffs are due to the modification of the Lucky Mc mill to a more modern and less labor-intensive facility, and to the reduced demand for uranium.

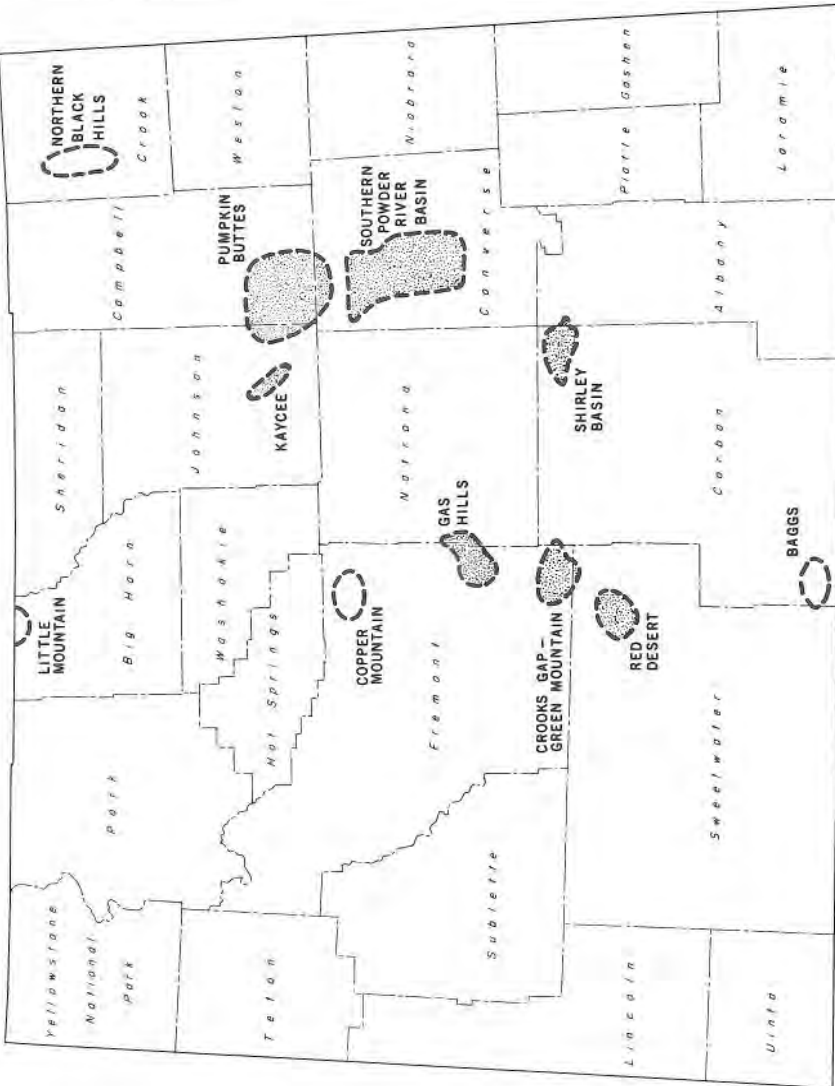
Wyoming's uranium industry has entered 1985 with five operating mines (COGEMA in Gas Hills, Crooks Gap, and Shirley Basin; Getty Oil Company in Shirley Basin; and Rocky Mountain Energy's Bear Creek Mining Company in the southern Powder River Basin) and four mills (COGEMA in Gas Hills and Shirley Basin; Getty Oil in Shirley Basin; and Rocky Mountain Energy in the southern Powder River Basin).

On an encouraging note, industry officials report that utilities are now beginning to plan purchases of uranium for electricity production because their current stockpiles are beginning to shrink. With most of the large oil companies out of the uranium business, there may be more opportunity for the smaller, traditionally-oriented uranium companies to resume mining. The main question is whether utilities will favor a domestic source of uranium, even at a slightly higher cost (the price of uranium virtually does not affect the cost of electricity) over foreign (mostly Canadian and Australian) uranium sources.

In February of this year, Saarberg Interplan, a West German Company, expressed interest in uranium exploration in Wyoming. Saarberg is apparently investigating uranium potential in both Wyoming and Texas.

Trona

Trona production is remaining steady at reduced levels with no large production increases foreseen. As seen in Table 1 (page 2), the Geological Survey



EXPLANATION

 Uranium district with active or recent mining

 Uranium district without recent mining

WYOMING GEOLOGICAL SURVEY, 1983

MAJOR ACTIVE AND INACTIVE URANIUM DISTRICTS

of Wyoming has revised its trona production forecasts to reflect this lack of anticipated growth.

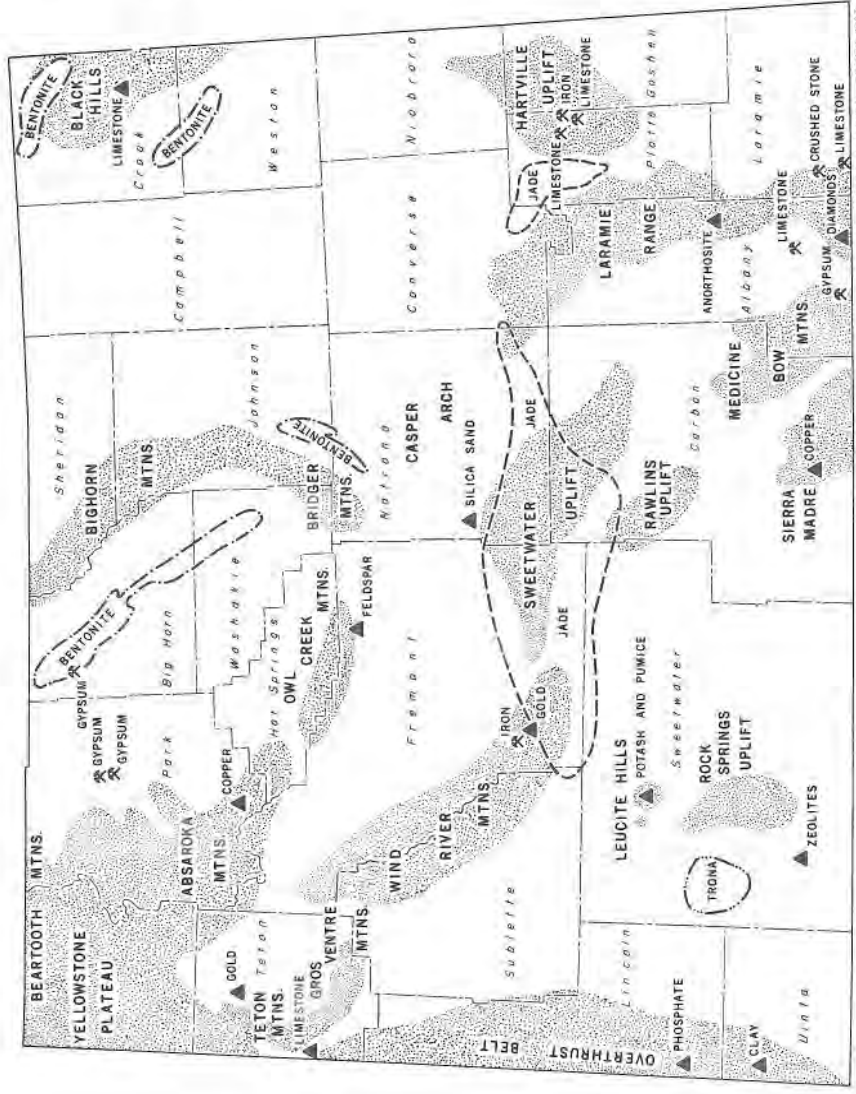
Allied Chemical Company announced that it was cutting production of soda ash from Wyoming trona and laying off more Wyoming workers while at the same time increasing production of soda ash from its synthetic soda ash plant in Syracuse, New York. According to an Allied spokesman, although Wyoming trona costs much less to produce, rail transportation costs make Wyoming soda ash more expensive on the east coast where most of the consumption of soda ash occurs. These transportation costs are one reason why the Wyoming trona industry has been unsuccessful in establishing an export market.

Bentonite

Bentonite production continues to grow in a market characterized by low prices. Consequently, revenue is down even though bentonite production has increased. Transportation costs are less of a factor in bentonite production than in trona production in Wyoming since Wyoming supplies most of the western bentonite used in the drilling, refining, and steelmaking industries, and high transportation costs affect all producers about equally.

Other Industrial Minerals

The production of gypsum, sand and gravel, and other industrial minerals is expected to increase in 1985. There is a possibility for substantial growth in sand and gravel production if the full MX missile program is approved. Specialty sand and gravel (aggregate) will be needed to produce the hardened concrete in the silo structures. Also, if the Chicago and North Western Railway extends its Powder



WYOMING GEOLOGICAL SURVEY, 1962

SELECTED MINERAL AND ROCK OCCURRENCES

EXPLANATION

- X Mines and quarries
- (---) BENTONITE
- (●) Bentonite mining district
- (○) TRONA
- ▲ Trona mining district
- ▲ Localities
- ▲ JADE
- ▲ Jade collecting areas
- ▲ Uplifted areas

River Basin line, additional ballast will be needed by late 1985 or 1986. Most of this ballast will probably come from the Lusk area since this was the source for the ballast used in the existing spur.

LEGISLATIVE UPDATE - 1985

Governor Herschler has signed a new bill called the Natural Gas Act. This Act, which amends Wyoming Statutes 15-1-103 and becomes effective May 23, 1985, is designed to lower natural gas prices by increasing competition. The new law permits cities to negotiate directly for cheaper gas supplies and requires local gas companies to deliver it to homes and businesses. In the past, utilities negotiated their own contracts for supplies with their contract subject to approval by the Wyoming Public Service Commission.

A city must obtain permission to negotiate its own supply contract by a majority vote of the electors of the city in a one-time election for that purpose. Unless affirmed by another act of the Legislature, the Natural Gas Act is repealed July 1, 1988.

The Governor signed two other bills giving tax breaks to segments of the oil industry, i.e., enhanced oil recovery projects and oil mining projects. Enhanced oil recovery projects, begun after July of 1985, would be subject to a severance tax of 1.5 percent for a period of five years, and then revert to the normal six percent in 1990. Oil mining projects would receive a cut from 12 percent to 1.5 percent in ad valorem and severance taxes also for a five-year period.

A bill which would have provided a severance tax break for production from wildcat wells was passed by

the Legislature this session but vetoed by Governor Herschler. The bill would have given a four percent severance tax break (reduced from six percent to two percent) for the first two years of production from a wildcat well.

The Wyoming Legislature failed to pass a bill setting a six percent severance tax rate on carbon dioxide (CO₂). This is the rate that the State contends is applicable to CO₂ anyway. Several attempts were also made to exempt or to reduce the severance tax rate for CO₂ that is used for enhanced oil recovery projects in the State of Wyoming. Some other bills related to oil and gas that were not passed included a bill to reinstate the oil and gas simultaneous drawings (commonly called the oil and gas lottery) and a bill to establish a position for an oil and gas forecaster in the Wyoming Oil and Gas Conservation Commission.

There were several bills introduced in the 1985 General Session related to the State's coal industry. An attempt to extend the two percent Coal Tax Revenue Account (Impact Tax), which is due to expire when revenues from the tax reach \$160 million, was not acted on. This tax is included in the State's base severance tax rate of 10.5 percent of the value of the coal; the tax has been in effect since 1975 and is used to help communities in the State mitigate impacts from coal development. Revenues from this tax have been used to finance construction and improvements of highways, roads, and streets as well as public water and sewer projects. The revenues collected so far from this tax are an estimated \$117,300,000 (Management Council, October, 1984, *Taxes on Wyoming's minerals: history and projections*: Legislative Service Office, Cheyenne, p. 33).

The tax is due to expire in late 1985 or early 1986. Opponents of the tax argued that increases in Federal royalties in the future would more than cover the loss in revenue when the Impact Tax expired. Accordingly, a bill that would substitute Federal royalties for Impact Tax royalties was introduced and passed. Under this bill, royalties in excess of \$200 million would be distributed as follows: 25 percent to current royalty revenue users; 37.5 percent to cities, towns, and counties; and 37.5 percent to an account that the Legislature can use at its discretion to mitigate impacts of mineral development.

Another bill concerning coal severance taxes was introduced during the Legislative Session, but failed. This bill was designed to give producers of high-cost coal an 80 percent severance tax credit on coal that exceeded \$10 a ton to produce, provided that the producer had coal reserves with an effective stripping ratio of 8-to-1 and that the producer had been mining continuously for 10 years. The bill was intended to give producers in southern Wyoming (especially the Hanna Basin) tax relief so they might compete more effectively with other producers.

In regard to the mineral industry in general, a bill was introduced that dealt with methods of assessing mineral value for tax purposes. The bill was not acted on. Another bill designed to defer or modify reclamation activities at certain remaining uranium operations was vetoed by Governor Herschler.

OIL AND GAS REGULATIONS PUBLISHED

The Wyoming Oil and Gas Conservation Commission has published a 1985 revision of their booklet, *Rules*

and regulations of the Wyoming Oil and Gas Conservation Commission. Since publication of the 1982 version of the booklet, "Rule 339 (Seismic Operations) was amended, four new definitions were adopted, all definitions were renumbered, and Forms 14A, 14B, 15, and 15A were adopted, effective April 16, 1984; Form OG001 was revised, effective July 1, 1984; Rule 326 (Pollution and Surface Damage) was amended, effective June 1, 1984; Rule 302 (Location of Wells) was amended, effective June 22, 1984; Rule 319 (Filing of Well Logs) was amended, effective August 17, 1984; and Rule 339 (Seismic Operations) was amended, effective December 28, 1984" (from page 3 of the new booklet).

In addition, the new booklet includes the amendment of Wyoming Statute 30-5-104, which created a new paragraph (V). This paragraph clarifies the Commission's authority to regulate the plugging, sealing, or capping of seismic shot holes as well as its authority to fix bonds to ensure compliance with its regulations governing all geophysical operations.

VALUE OF NONFUEL MINERALS IN 1984

The value of nonfuel mineral production in Wyoming in 1984 was estimated at \$525.4 million, according to the Bureau of Mines, U.S. Department of the Interior. This was about 17 percent below 1983 and 32 percent below the peak year of 1981. The interyear decline was due to the lower value of sodium carbonate (soda ash) produced and the cessation of iron ore production in the State. Although still accounting for more than three-fourths of the nonfuel mineral total, the value of sodium carbonate produced declined about 18 percent, although volume of output was only slightly lower than in 1983. (See Table 5, page 36).

Table 5. Nonfuel mineral production in Wyoming¹.

Nonfuel mineral production in Wyoming¹

Mineral	1983		1984 p/	
	Quantity (thousands)	Value (thousands)	Quantity (thousands)	Value (thousands)
Clays-----thousand short tons--	2,140	\$ 49,059	2,713	\$ 66,569
Gem stones-----	NA	250	NA	225
Gypsum-----thousand short tons--	382	2,963	424	3,477
Sand and gravel (construction)-----do--	e/2,400	e/8,000	3,900	10,800
Stone (crushed)-----do--	2,019	7,769	2,800	10,000
Combined value of beryllium concentrate (1983), cement (portland), iron ore (1983), lime, and sodium carbonate-----	XX	561,860	XX	434,361
TOTAL-----	XX	629,901	XX	525,432

e/= estimated p/= preliminary NA= not available XX= not applicable

¹ Production as measured by mine shipments, sales, or marketable production (including consumption by producers). This Annual, Preliminary Mineral Survey was prepared by Karl E. Starch of the U.S. Bureau of Mines in cooperation with the Geological Survey of Wyoming. For information on the mineral survey call (303) 236-0438.

TOPOGRAPHIC MAP PRICES INCREASE

Because the U.S. Geological Survey raised its prices, we have had to raise ours as well. Our over-the-counter prices for the 7.5-minute and 15-minute standard topographic quadrangle maps increased from the old price of \$2.25 each up to \$2.50 per map. Prices increased from \$3.60 up to \$4.00 for topographic, planimetric, and shaded-relief state base maps, published at a scale of 1:500,000; quadrangle maps at a scale of 1:100,000; regional topographic maps (AMS-series) at a scale of 1:250,000; and maps of national parks.

On mail orders, our 7.5-minute topographic maps are \$2.75 per map; AMS-series maps are \$4.25 each. A reminder - mail orders for topographic maps must be prepaid. We send them first class and folded. Sorry, no refunds/no exchanges on these orders.

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NEW HIGH-ALTITUDE PHOTO FORMAT

Users of 1:24,000-scale topographic maps now have a new interpretation tool: up-to-date aerial photographs produced at the same nominal scale as the map sheets they work with.

The photos are a new product available from the EROS Data Center, a facility of the U.S. Geological Survey National Mapping Division, which has been archiving original film acquired under the National High-Altitude Photography (NHAP) Program for the past six years. Until now, getting an NHAP photo at a common map scale like 1:24,000 required a custom-made enlargement with a heavy surcharge at order time.

The National Mapping Division has decided to standardize that enlargement factor and to remove the surcharge. Prints are available for as low as \$25 for a black-and-white product, \$50 for color infrared.

Most map users can benefit from having an aerial view of their area of interest because in many cases U.S. Geological Survey topographic maps were compiled some years ago and have not been updated recently. All NHAP imagery is at least as recent as 1978. Using a NHAP aerial photo can thus be an excellent means of supplementing the information on a topographic map. Landowners and surveyors, for example, can use these photos to check and update their information on rights-of-way, roads, landmarks, or any number of features that might not show up on a map.

The applications for urban planners, utility companies, Forest Service workers, sportsmen, and many, many other serious users of 1:24,000-scale maps include a broad range of updating, upgrading, and map

verification activities that can save valuable time in the field.

Both the black-and-white and the color products are provided on 30-inch photographic paper. A standard enlargement factor is applied to the black-and-white products to bring them up to a nominal scale of 1:24,000. The color infrared products, which are acquired by a different camera, are enlarged just 2.43 times to achieve the desired nominal scale. Although the enlargement factors are carefully controlled, program personnel are careful to point out that these are not orthophotos or rectified products in anyway. Original NHAP imagery, while offering minimal variations in scale, is acquired and held as is, with no additional processing to normalize within-image distortion caused by ground features. All NHAP scales are therefore "nominal."

Complete information on areas covered, NHAP acquisition specifications, and the ordering procedure to use when requesting these new 1:24,000-scale products is available from either of the following offices:

U.S. Geological Survey
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U.S. Geological Survey
Rocky Mountain Mapping Center
National Cartographic Information Center
Mail Stop 504, Denver Federal Center
Denver, CO 80225
(303) 236-5829

RECENT AND NEW PUBLICATIONS

Bibliography of Wyoming geology, 1960-1969, by Charlotte Tancin, Bulletin 64, 1984 (\$8.00).

Index to selected U.S. Geological Survey Bulletins that contain geologic maps for Wyoming, compiled by Rodney H. DeBruin, Map Series MS-9G, 1984 (\$2.50).

Index to selected U.S. Geological Survey Professional Papers that contain geologic maps for Wyoming, compiled by Rodney H. DeBruin, Map Series MS-9H, 1984 (\$2.50).

Self-guided tour of the geology of a portion of southeastern Wyoming, by W. Dan Hausel and Richard W. Jones, Public Information Circular 21, 1984 (\$6.00).

Tour guide to the geology and mining history of the South Pass gold district, Fremont County, Wyoming, by W. Dan Hausel, Public Information Circular 23, 1984, (\$4.50).

Alteration and mineralization associated with sandstone uranium occurrences, Morton Ranch area, Wyoming, by Ray E. Harris, Report of Investigations 25, 1984 (\$7.00).

Geothermal resources of the Laramie, Hanna, and Shirley Basins, Wyoming, by Bern S. Hinckley and Henry P. Heasler, Report of Investigations 26, 1984 (\$7.00).

Analyses and measured sections of 25 coal samples from the Hanna Coal Field of southcentral Wyoming, by Gary B. Glass and Jay T. Roberts, Report of Investigations 27, 1984 (\$8.00).

Coal mining in Wyoming, compiled by the Wyoming Highway Department, 30-page map atlas with short text, 1984 (\$10.00).

Oil and gas map of Wyoming, compiled by Thomas R. Stephenson, Alan J. VerPloeg, and Lori S. Chamberlain, Map Series MS-12, 1984 (\$10.00).

Paleontology of the Green River Formation with a review of the fish fauna, Lance Grande, Bulletin 63, 1984 (2nd edition, revised) (\$12.50).

**Fifty-first annual report of the Geological Survey of Wyoming*, by Gary B. Glass, 1984 (free).

**A field guide to the Casper Mountain area*, by Wyoming Field Science Foundation, Reprint 45, 1978 (\$6.50).

**Summary of coal contracts with Wyoming mines*, compiled by Gary B. Glass, available in xerox format only, January, 1985 (\$15.00).

**Selected references on construction materials in Wyoming*, by Ray E. Harris and John E. Meyer, Open File Report 85-2, 1985 (\$2.25).

**Foreland compressional tectonics: southern Bighorn Basin, Wyoming*, by D.L. Blackstone, Jr., Open File Report 85-3, 1985 (\$9.00).

**Extent of coal-bearing rocks and locations of coal mines in the Bighorn Coal Basin, Montana and Wyoming*, by Suzanne C. Luhr and Richard W. Jones, Open File Report 85-4, map at 1:250,000 scale, 1985 (\$4.00).

**Economic geology of the Copper Mountain supra-crustal belt, Owl Creek Mountains, Fremont County, Wyoming, by W. Dan Hausel, Paul J. Graff, and Karl G. Albert, Report of Investigations 28, 1985, (\$8.00).*

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